EVALUATION OF THREE SASKATCHEWAN BENTONITES AS PLASTICIZERS FOR BRICK SHALES

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INTRODUCTION

An agreement was reached with Avonlea Mineral Industries Ltd., Regina, Saskatchewan, to evaluate three types of bentonite as plasticizers for brick shales, using the Brabender Plastograph in the Ceramic Section, Mineral Sciences Laboratories.

The bentonite samples were marked "DG", "SG" and "SSG". Two shale samples were supplied by Canada Brick Company Ltd., Streetsville, Ontario, and were described as production-ground Queenston shales identified as "Streetsville" and "Burlington". It was agreed that each bentonite would be examined at addition levels of 0.5, 1.0, 2.0 and 4.0 % in each shale.

Prior to use, the shales were oven-dried for 24 hours at 105°C. The bentonites were used in the as-received condition, maintained by keeping the samples sealed in the original plastic bags.

PROCEDURE

The test procedure followed was that normal to this laboratory, with modification as found necessary to the occasion. The mixing chamber of the Plastograph was charged with 200 g of the shale to be tested: this fills the chamber level with the center of the shafts, providing optimum mixing. Additions of bentonite were made at levels of 0.5, 1, 2 and 4 % of dry weight of shale (1, 2, 4 and 8 g respectively). At the two lower additions, the bentonites were slurried in 20 g of water, (10 % by weight of shale) added slowly to the mixer in operation and allowed to mix for an additional 5 minutes to ensure uniform dispersion. Additions of 2 and 4 % bentonite in 10 % water formed gels that did not disperse well in 5 minutes of mixing, hence the bentonite was added dry and thoroughly mixed, then the first 10 % water was added and mixed for 5 minutes. Water was then added continuously at the rate of 0.5 % (one g) per minute to the conclusion of the run.

RESULTS

A typical Plastograph curve is shown in Fig. 1, illustrating the mode of interpolation. With increasing water addition, the consistency increases to a maximum, tends to level off for an interval, although the material be-

comes softer, and then decreases as the material becomes overwet. Ideally, the optimum water addition would correspond to the point where the rising curve levels off, where optimum green strength and extrudability should coincide. However, many stiff-mud products are extruded with less than this amount of water in order to develop sufficient stiffness to allow direct setting many courses high on kiln cars and to minimize energy requirements for drying. In this case the slope of the rising curve is a measure of the degree of control necessary for water addition: a too-steeply rising curve would indicate change from too stiff to too soft with a change in water content too small for adequate control. For soft-mud and/or jiggered bodies, the breadth of the upper (level) portion at the curve would indicate the working range where optimum forming properties would be expected.

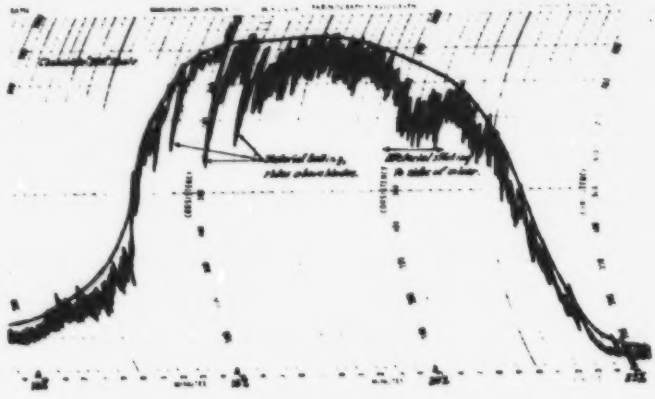

Fig. 1. Interpolation of Plastograph Curve

The results for additions of bentonites DG, SG, and SSG to the Burlington and Streetsville shales are shown in Fig. 2 - 7. It should be noted that the horizontal axis refers to the water added in per cent of dry weight of shale, and not the water content of the wet paste.

DISCUSSION

The Plastograph curves of the raw shales are shown on Fig. 2 - 7 for purposes of comparison. Both show an initial small peak rising above the general level of the main broad peak, most pronounced for the Streetsville sample. Experience has indicated this behaviour is related to dilatency (increased resistance to shear with increased time or rate of shear), probably resulting from the presence of silt-sized pseudo-plastic material in the mixture. This characteristic can cause "bleeding" behind the die of the extruder and the build-up of a hard, non-plastic mass that impedes proper flow of the material through the die. Very sharp, high-rising peaks of this type have been related to formation of lamination in extruded bricks.

Burlington Shale

The peak height of 800 metre-grams of torque recorded for the Burlington material is well above the minimum (circa. 600 m-g) for satisfactory extrusion of mechanically sound brick, but below the level indicated by experience for satisfactory extrusion of hollow block (about 900 m-g).

Additions of all three bentonites increase the peak height, and hence the extrudability of the shale, Fig. 2 - 4. Bentonites DG and SG are more effective, at least at lower levels, than SSG: additions of 1% raise the peak height above the 900 m-g level. Furthermore, the addition of plastic bentonite counteracts the dilatent effect of the pseudo-plastic components of the shale, producing a smooth peak although, again, more of the SSG bentonite is required to achieve this effect. This is accomplished at the expense of peak width (of less importance to extrusion forming than to jiggering) and with a more sharply rising curve that would require more careful control of water content. At the higher levels of bentonite addition, 2 and 4 %, there is proportionately less difference in effectiveness between the three types of bentonite. (The anomalous behaviour of 2 % bentonite SG remains unexplained; may possibly be due to sampling of either the shale or bentonite although care was taken to avoid separation of the materials). The exceedingly sharp rise of these curves would be expected to make pugging control very difficult: however, in these cases the bentonite was added dry and the delay in recorded increase of consistency may reflect the need to first wet a sufficient amount of surface of the materials, particularly of the fine-grained, high surface area bentonite.

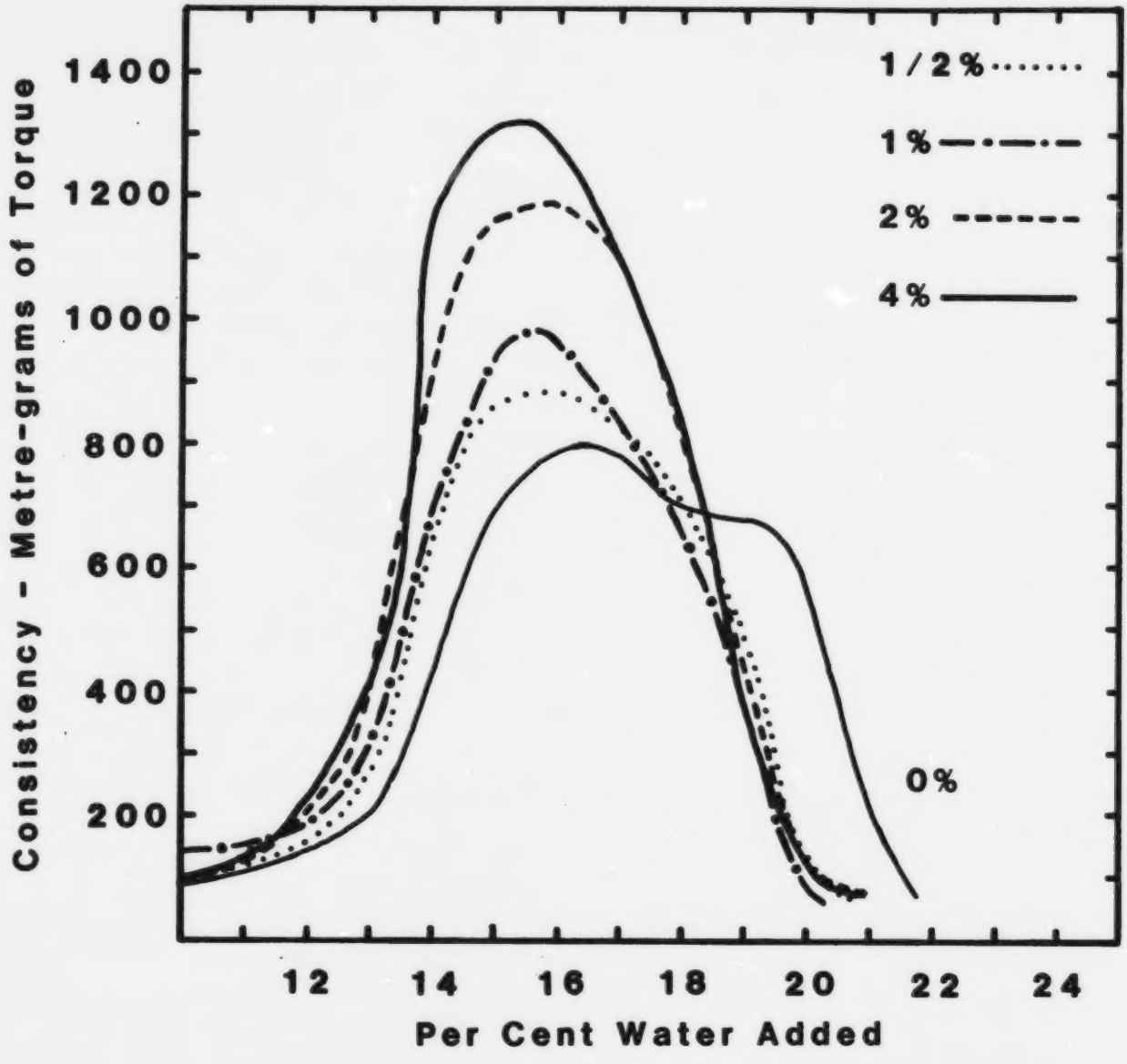

Fig. 2 - Plastographs of "Burlington" shale with additions of bentonite "DG"

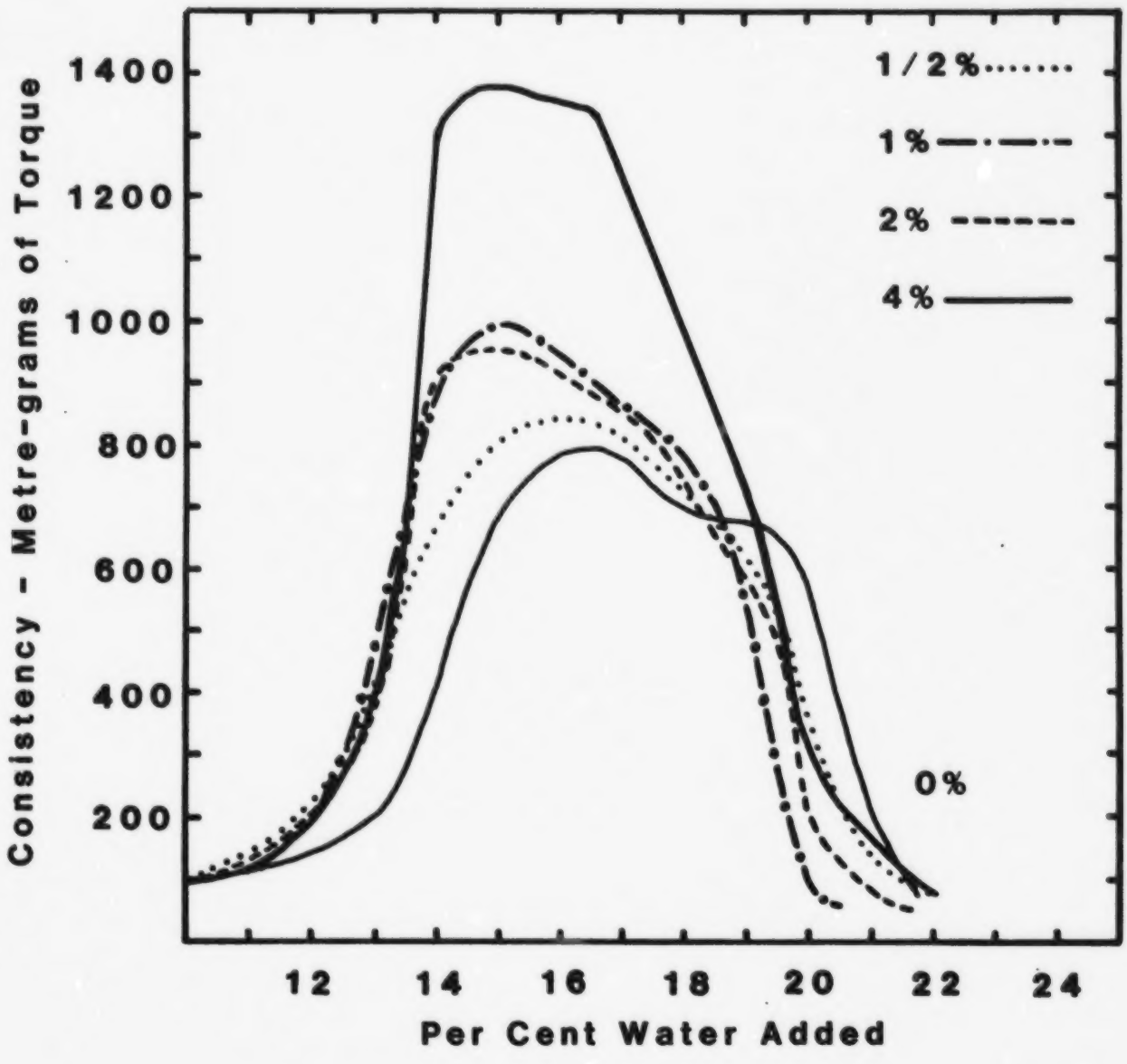

Fig. 3 - Plastographs of "Burlington" shale with additions of bentonite "SG"

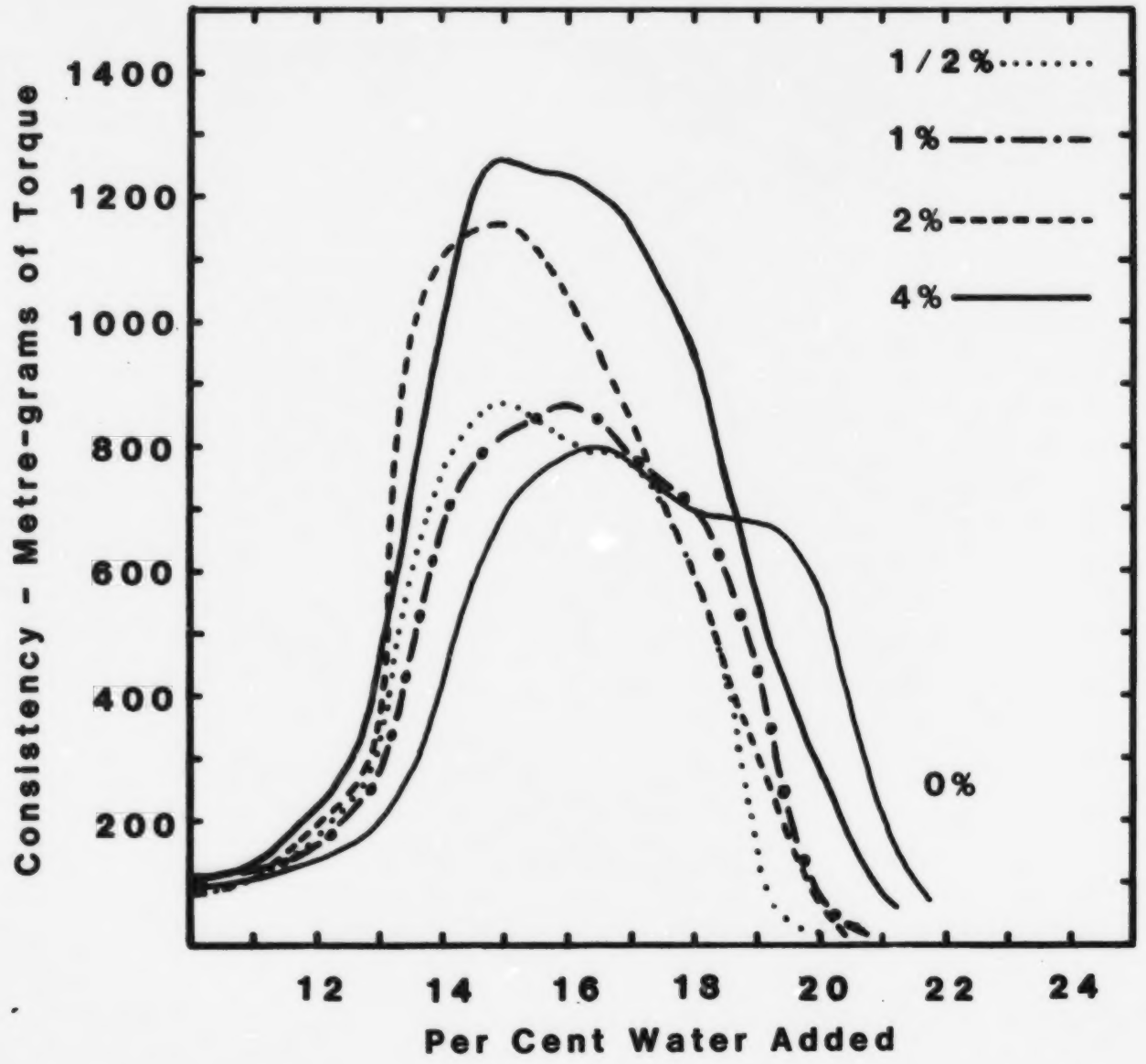

Fig. 4 - Plastographs of "Burlington" shale with additions of bentonite "SSG"

Streetsville Shale

The raw Streetsville material exhibits a maximum dilatent peak height of about 1130 m-g torque although the level of the main curve reaches about 1000 m-g. This is considered adequate for satisfactory extrusion of brick and/or hollow block, although there is a risk of bleeding behind the die. Additions of bentonite counteracted this dilatent tendency of the shale.

Again, the SG bentonite appears least effective in increasing the consistency and also in negating the dilatent behaviour of the shale, Fig. 5 - 7. Again too, there is an anomaly in the progressive change in the curve with increasing bentonite (Fig. 6, 1 %), which remains unexplained although it was confirmed by repeating the test.

With this shale, the lower additions of the bentonites reduce the slope of the rising curve, promising greater ease of pugging control. This effect carries through the 2 % addition of bentonites DG and SSG. With 4 % additions the curve rises more steeply (less easily to control): again, this may be a Plastograph feature, where the procedure does not provide sufficient time for progressive wetting of the high surface area of the bentonites.

CONCLUSIONS

Additions of bentonite improve the extrudability of the shales by increasing their consistency, as recorded by the Plastograph, and by counteracting the dilatent tendencies of the shales. Bentonites SSG and DG are similar in effectiveness with both shales, with the DG material offering slightly more improvement in most cases. Bentonite SG is less effective than the other two types: in addition it displays anomalies with both shales that lead to some question as to its reliability in use.

ACKNOWLEDGEMENTS

The contributions of G. Lemieux and L.K. Zemgals, technicians, Ceramic Section, who performed the tests and prepared the curves, are gratefully acknowledged.

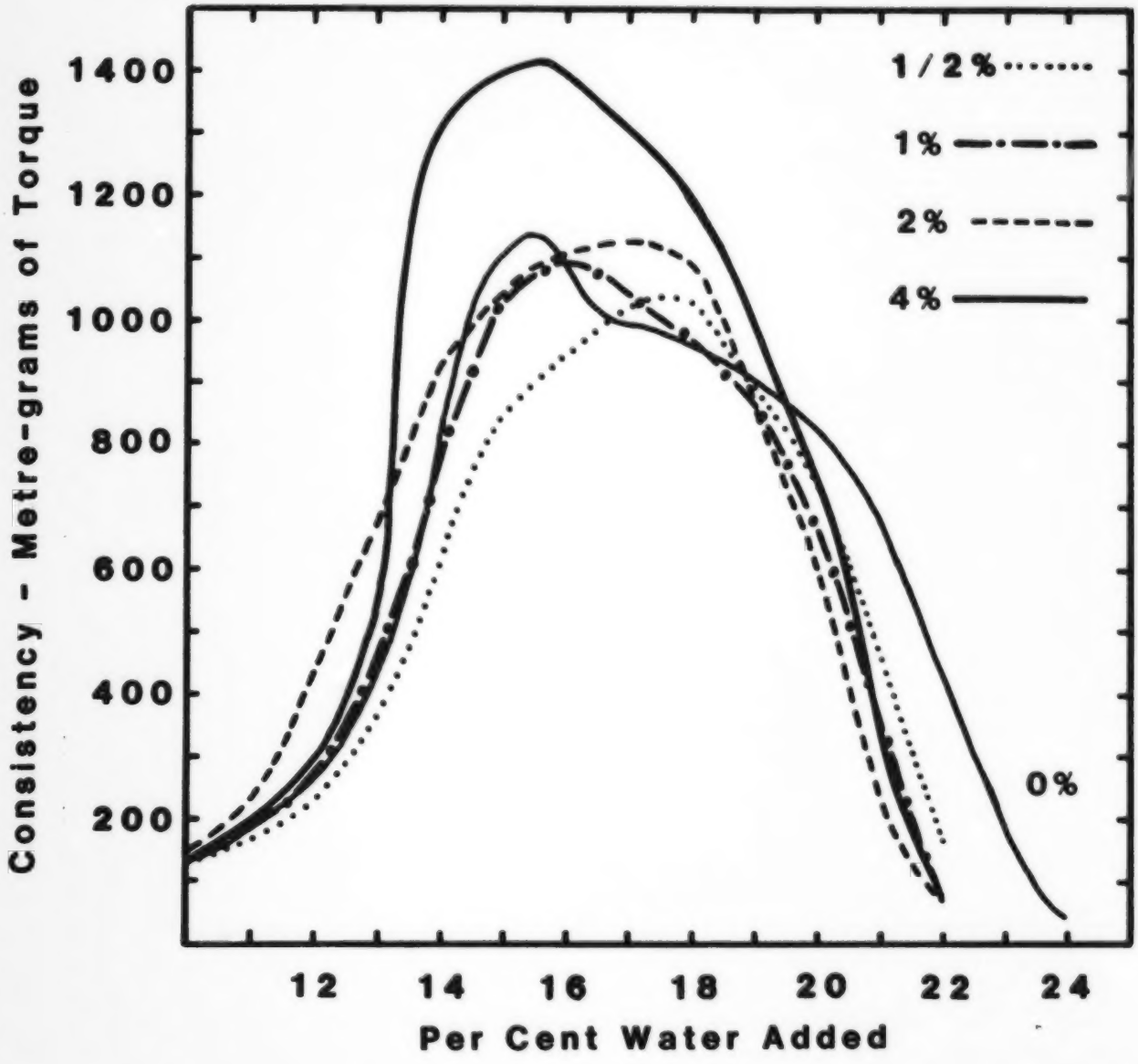

Fig. 5 - Plastographs of "Streetsville" shale with additions of bentonite "DG"

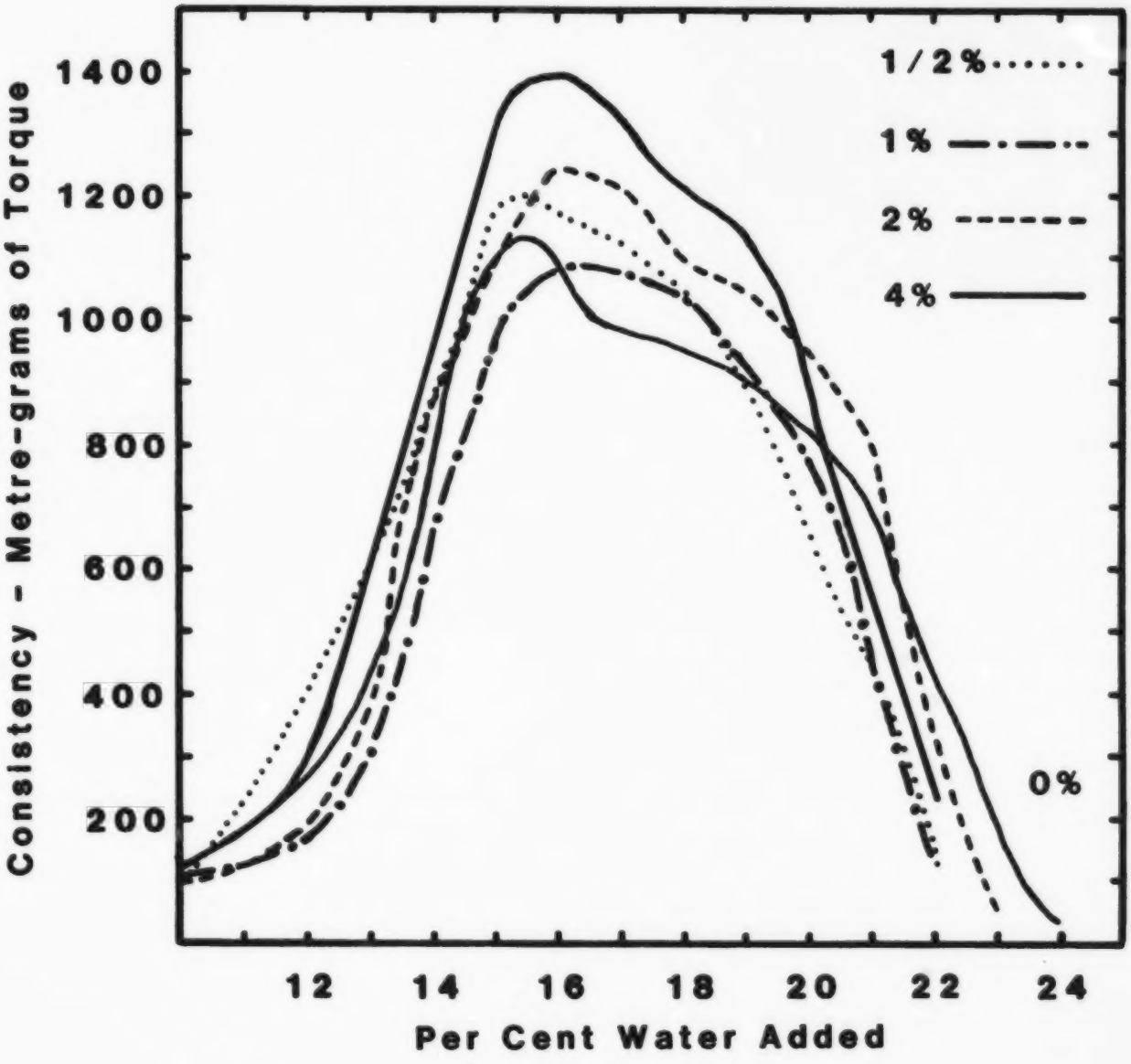

Fig. 6 - Plastographs of "Streetsville" shale with additions of bentonite "SG"

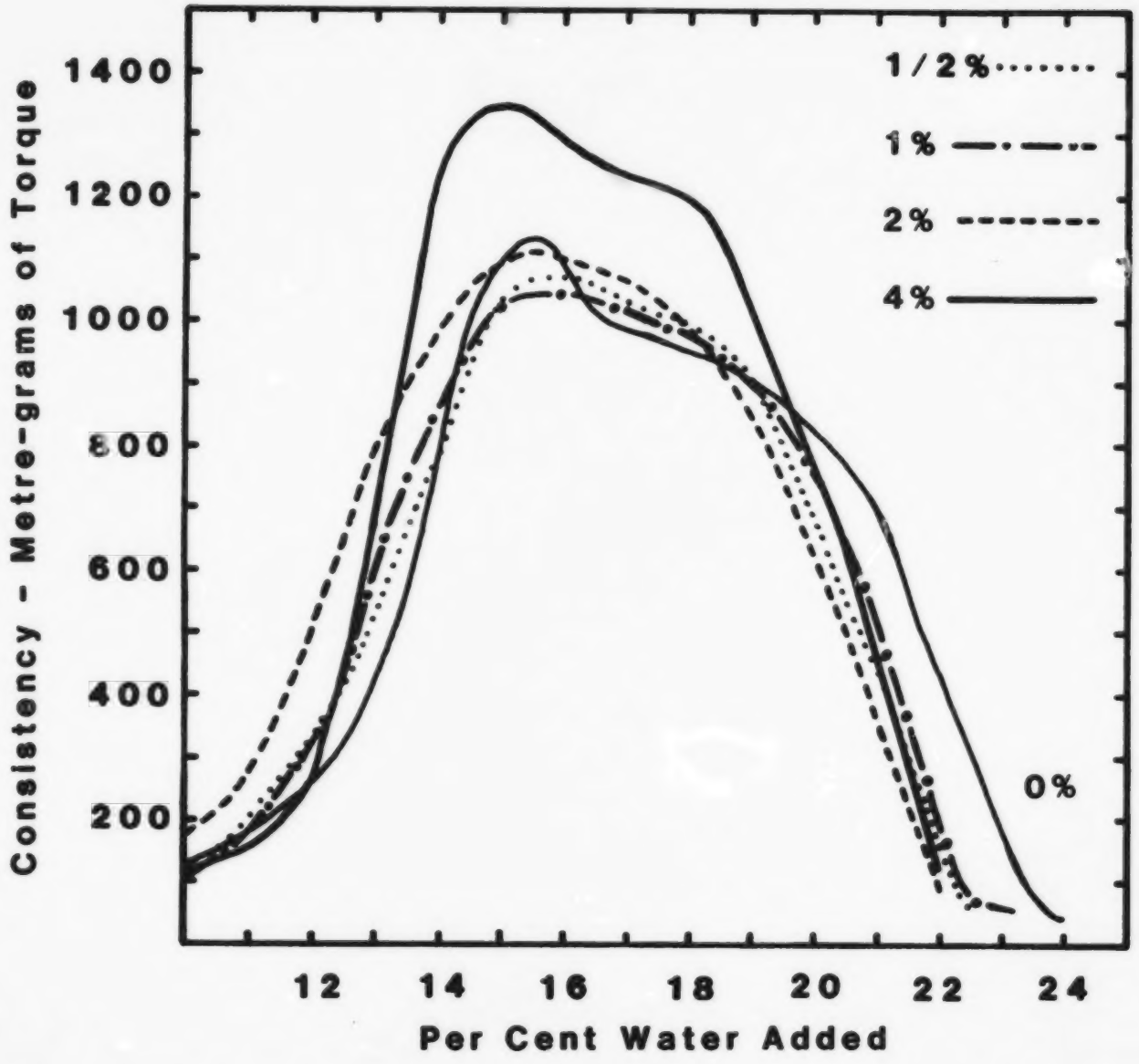

Fig. 7 - Plastographs of "Streetsville" shale with additions of bentonite "SSG"